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ABOUT THE AUTOMATED STORAGE SYSTEMS FOR PALLETS

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Abstract: The using of Automated storage and retrieval system (AS/RS) allow users to optimize storage space and increase the efficiency of managing all processes in them. The main problem for optimization in AS/RS is principally on travel time estimates and different control policies such as dwell-point of the stacker crane, storage assignment, request sequencing and so on. The paper presents comparison between AS/RS types, storage technologies used and types of storage machines. The opportunities to optimize the processes in these AS/RS are presented.

Keywords: Automated storages, electric lifts trucks, stacker cranes, optimization

Introduction

Automated Storage and Retrieval Systems (AS/RSs) are warehousing systems that are used for the storage and retrieval of products in both distribution and production environments [1]. The place of AS/RS in the automated factory has been assured because AS/RS systems have revolutionized the material handling and material control functions in manufacturing and distribution facilities throughout the world. These systems have broad application and have been effectively adapted to enhance productivity in all areas of the business environment where materials are required to support business objectives.

There are three types of AS/RS devices called Vertical Lift Modules (VLMs), Horizontal Carousels and Vertical Carousels. These systems are used either as standalone units or in integrated workstations called pods. These units usually are integrated with various types of pick to light systems and use either a microprocessor controller for basic usage or inventory management software. These systems are ideal for increasing space utilization up to 85%, productivity levels by 2/3, accuracy to 99.9%+ levels and throughput up to 750 lines per hour/per operator.

A distribution center typically has similar functions with the exceptions of manufacturing and assembly. There are six major processes exist in most manufacturing facilities with material handling serving as the vital link which enables each one to interface with the others. They are: Receiving, Inspection, Picking, Manufacturing, Assembly and Shipping.

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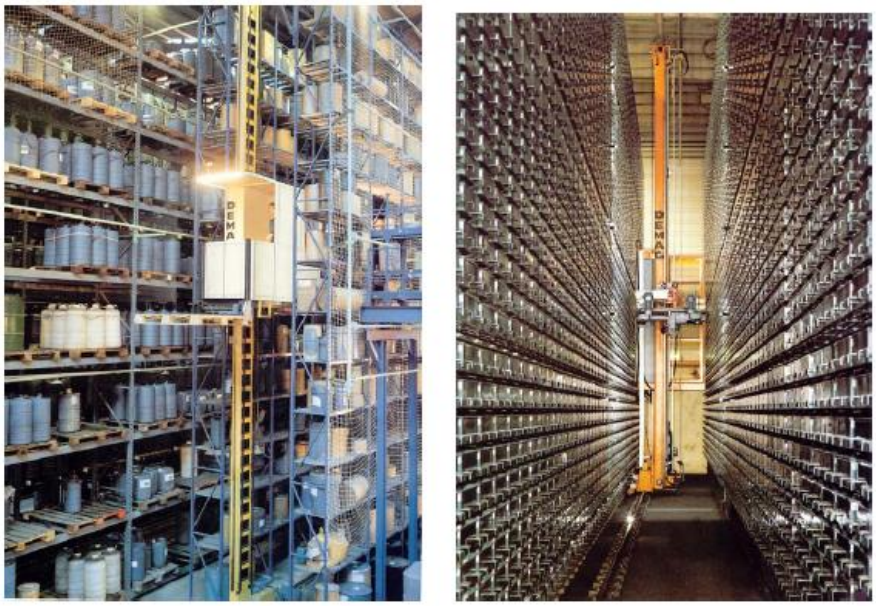

Figure 1. Automated storage and retrieval systems

Compared to standard warehouses (large warehouses with a height of storage up to 6 m, serviced by universal high-lift trucks or bridge cranes), the high-rise warehouses and especially the automated ones are distinguished by their much higher height, which in some cases reaches up to 45 m , but most often it is 12 - 26 m.

High-rise warehouses are subdivided into non-self-supporting buildings when the racking block is located inside a separate building and self-supporting when the high-rise block supports the roof, walls and engineering communications.

The following main processes are carried out in each warehouse:
- acceptance
- storage
- expedition

Depending on this, the following main zones (subsystems) - "Acceptance" (П), "Storage"(С) and "Expedition" (Е) are organized in the warehouses.

They can be located either linearly (a), angularly (b), or U-shaped (c). Small reception area (d) is allowed for small warehouses.

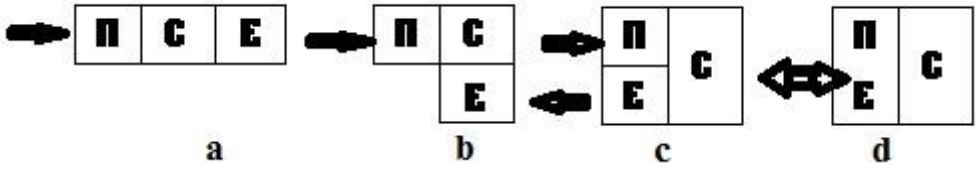

Figure 2 Location of warehouse areas

In the receiving zone there are following processes:
• unloading the vehicle
• sorting loads by type
• quantitative and qualitative cargo control
• formation of consolidated storage units

In the storage zone there are:
• stacking loads
• periodic control

In the expedition zone there are:
• sorting and grouping of loads along routes
• quantitative and qualitative batch control
• Formation of freight forwarding units (for external transport)
• loading of the internal transport vehicle

As/Rs Types and Elements

The main components of an AS/RS are racks, cranes, aisles, I/O-points, and pick positions. Racks are typically metal structures with locations that can accommodate loads (e.g., pallets) that need to be stored.
Cranes are the fully automated storage and retrieval machines that can autonomously move, pick up and drop off loads. Aisles are formed by the empty spaces between the racks, where the cranes can move. An input/output point (I/O-point) is a location where retrieved loads are dropped off, and where incoming loads are picked up for storage. Pick positions (if any) are places where people are working to remove individual items from a retrieved load before the load is sent back into the system [2].

The following are the principal types:

- Unit-load AS/RS. The unit-load AS/RS is typically a large automated system designed to handle, unit-loads stored on pallets or in other standard containers. The system is computer controlled, and the stacker cranes are automated and designed to handle unit-load containers. The unit-load system is the generic AS/RS. Other systems described below represent variations of the unit-load AS/RS.
- Deep-lane AS/RS. The deep-lane AS/RS is a high density unit-load system that is appropriate when large quantities of stock are stored, but the number of separate stock types is relatively small. The loads can be stored to greater depths in the storage rack and the storage depth is greater than two loads deep on one or both sides of the aisle.
- Miniload AS/RS. This storage system is generally smaller than a unit-load AS/RS and it is used to handle small loads (individual parts or supplies) that are contained in small standard containers, bins or drawers in the storage system. A miniload AS/RS works like a unit-load system, except that the insertion/ extraction devices are designed to handle standard containers, totes or trays that store pieces, components and tools instead of unitized loads.
- Man-on-board AS/RS. A man-on-board (also called man aboard) storage and retrieval system represents an alternative approach to the problem of retrieving individual items, from storage. In this system, a human operator rides on the stacker crane's carriage.
- Automated item-retrieval system. These storage systems are also designed for retrieval of individual items or system product cartons; however, the items are stored in lanes rather than bins or drawers.
- Vertical lift storage modules (VLSM). These are also called vertical lift automated storage/retrieval system (VL-AS/RS). All of the preceding AS/RS types are designed around a horizontal aisle. The same principle of using a center aisle to access loads is used except that the aisle is vertical. Vertical lift modules, some with height of 10 m (30 foot) or more, are capable of holding large inventories while saving valuable floor space in the factory.

The Advantages of automated storage systems for pallets are [2]:

- An efficient AS/RS system helps companies cut expenses by minimizing the amount of unnecessary parts and products in storage, and improving organization of the contents of a warehouse.
- Automation reduces labor costs while lowering workforce requirements and increasing safety.
- Modeling and managing the logical representation of the physical storage facilities.
- Enabling a seamless link to order processing and logistics management in order to pick, pack, and ship product out of the facility.
- Tracking where products are stocked, which suppliers they come from, and the length of time they are stored.

The main machines in AS/RS are stacker cranes. They are machines with a cyclical action, hence their output is calculated on the basis of the time to perform a medium duty cycle. The determination of the times of some of the movements is done by statistical data as it can not be determined by the nominal speeds of the mechanisms.

The working cycle of stacker crane when placing a load in the racking cell generally consists of the following movements; loading of cargo / long-haul pallets / from the receiving cage (in this case mostly the roller conveyor), traveling to the corresponding pallet space 3 rack / rack / cargo racking, loading, returning / repeating the same movements but in reverse sequence and direction.

Thera are two types stacker cranes in AS/RS. One – column and two-column stacker crane.
The times of insertion and seizure cycles are the same on the same paths due to the same gear speeds in both directions.

Pallet shuttle AS/RS solutions provide maximum efficiency with deep storage lanes and also reduces the need for forklifts to store and retrieve pallets. By using a cart system to transport pallets into the buffer, forklifts no longer need to travel beyond the shipping dock and lane entry. Shuttles can move pallets in and out of storage as well as the benefit of some solutions providing "lifter" options to move pallets vertically through any level of

storage. Pallet shuttle AS/RS provides an automated solution that innovates traditional storage and retrieval operations with unparalleled speed and accuracy [4].

Figure 3 types pallet shuttle [5], [6]

Characteristics in the Organization of the Operation of Automated High-Rise Warehouses

The organization of work in automated high-rise warehouses compared to traditional low-walled warehouses is characterized by the following non-essential features:

- Each incoming in-store pallet must be accompanied by a document containing the basic data of the goods (commodity-valuables) and the pallet
- All pallet storage locations in the high-density block should have a unique address. Each address is formed in accordance with a pre-adopted coding system.

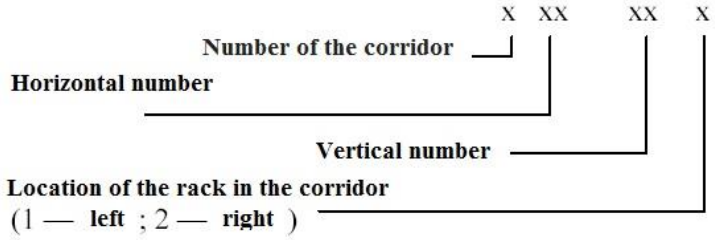

Figure 4. Example of cargo coding in the automated warehouse

There are some strategies for storage in AS/RS:

- first strategy - fi-fo – first in – first out
- second strategy - expiry date;
- third strategy - - the partially filled pallets of each nomenclature type of cargo shall be dispatched with priority;
- fourth strategy - seizure of pallets with minimum time from the Warehouse area to the Expedition area;
- fifth strategy - combined with several strategies.

Modeling and Optimization of As/Rs

Modeling is a powerful tool for researching warehouses.
The greatest need for modeling arises when investigating the movement of material flows in the warehouse due to the dynamics of the process.

When designing warehouses by modeling, the optimal parameters of the warehouse can be determined, their locations can be found, rational options in the technology, the organization and the management of the warehouse, etc.

Random warehouse processes are modeled very successfully through statistical modeling.
The statistical models are applied in cases where the likelihood of occurrence of different events, as well as the most probable parameters of the storage processes, have to be established [3].

In statistical modeling, instead of a mathematical analysis of the characteristics of the studied system, the process of the process is reproduced. In this respect, the Monte-Carlo method is particularly appropriate.

The input stream is generally random stream and is considered to be determined when the probability law is known to be the time interval between requests t and the number of requests n.

The main concepts used in optimization are:

- design parameters - the unknown values to be defined in the optimization process,
- a quality criterion - an expression the designer wants to maximize or optimize.

The optimization of the productivity of the storage machines depends on the determination of the average / equivalent / cycle parameters - X and Y where x_i , y_i the coordinates of the respective cell are. In the determination of X and Y, there are two possibilities depending on the use of pallet locations / racking cells /. It is also likely that the storage cells are used randomly (stochastic) [3].

A number of studies have found that accidental filling of the cells in the unilaterally closed / butt-stuffed / warehouses most often fill the cells closest to the starting site, whereas in the case of the most intensive use, the cells present in the near the floor.

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